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A Robust Methodological Approach for Mine Site Water Accounting

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ABSTRACT

Over the past decade, the mining industry has come to recognise the importance of water both to itself and to others. Water accounting is a formalisation of this importance that quantifies and communicates how water is used by individual sites and the industry as a whole. While there are a number of different accounting frameworks that could be used within the industry, the Minerals Council of Australia's (MCA) Water Accounting Framework (WAF) is an industry-led approach that provides a consistent representation of mine site water interactions regardless of their operational, social or environmental context that allows for valid comparisons between sites and companies.

The WAF contains definitions of offsite water sources and destinations and onsite water use, a methodology for applying the definitions and a set of metrics to measure site performance. The WAF is comprised of two models: the Input-Output Model, which represents the interactions between sites and their surrounding community and the Operational Model, which represents onsite water interactions.

Members of the MCA have recently adopted the WAF's Input-Output Model to report on their external water interactions in their Australian operations with some adopting it on a global basis. To support this adoption, there is a need for companies to better understand how to implement the WAF in their own operations. Developing a water account is non-trivial, particularly for sites unfamiliar with the WAF or for sites with the need to represent unusual features. This work describes how to build a water account for a given site using the Input-Output Model with an emphasis on how to represent challenging situations.

INTRODUCTION

Within the mining industry securing a consistent supply of water through responsible management is vital to ensure production, achieve positive social and environmental outcomes and maintain a social licence to operate. The importance of water has been recognised by the mining industry and over the last decade and there has been an increase in the disclosure of water use at industry, company and site scale. However, as sites and companies have historically used different definitions to report on water use, comparisons and aggregation across companies and sites were invalid.

The Minerals Council of Australia's (MCA's) Water Accounting Framework (WAF) (Minerals Council of Australia, 2012) has been developed as part of an industry-led academic initiative to resolve this problem. The WAF presents a 'whole-of-site' systems view of mine water interactions and provides: a set of standard definitions for water sources, destinations, quality categories and states; a consistent methodology for applying these definitions across mine sites regardless of their operational, environmental or social context and the construction of consistent reports that allow for valid comparison.

The WAF enables the mining industry to benchmark performance and identify opportunities for improvement and also to clearly communicate the mining industry's water interactions to external stakeholders. The WAF is conceptually comprised of two models: an Input-Output Model that represents water interactions between a site and its outside environment and an Operational Model that represents water interactions within a site. This means that the WAF connects onsite water interactions to offsite impacts. The Input-Output and Operational Models are presented in **Error! Reference source not found.**

<<Insert Figure 1 Here>>

Implementation of the WAF began with 12 coal mines in the Bowen Basin (Moran et al., 2006) and followed by 9 coal sites in the Hunter (Cote and Moran, 2009). Since then, it has been applied, mostly by members of the Centre for Water in the Minerals Industry, to over 60 mines sites of various commodities (including: gold, silver, iron ore and copper) across four continents. This application has demonstrated the flexibility of WAF. The authors have been actively involved in implementing the WAF over the past five years and have actively engaged with industry during this implementation, produced a user manual (Minerals Council of Australia, 2012) and presented the WAF at numerous workshops to over 200 industry professionals.

In 2011, members of the MCA agreed to adopt the Input-Output Model within Australian operations, with a view to adopt the Operational Model at a later stage. This adoption required members: to align their internal water definitions with the WAF definitions; to use the WAF definitions when publicly reporting on their water interactions and to report to the MCA using the WAF definitions. BHP Billiton has also agreed to adopt the WAF throughout its operations globally (BHP Billiton, 2013). These developments have resulted in a significant expansion of the number of mines that will need to adopt the WAF since the MCA alone represents up to 85% of production (Minerals Council of Australia, 2013) from Australia's 400 mines (Geoscience Australia, 2013). This presents new challenges for the WAF's implementation because, for the first time, a large number of onsite personnel will be primarily responsible for developing the Input-Output Models rather than a small number of university researchers. This increases the potential for inconsistent applications in areas such as: identifying who should be developing the account; identifying the site's water sources and destinations; identifying which water flows need to be included in the account and which do not; identifying information sources and gaps for flow volumes and qualities; estimating reasonable values for information gaps; differentiating between water that is used for onsite activities and water diverted around onsite activities and understanding the environmental and social context in which a site operates.

This paper aims to address these challenges by presenting a robust methodology for applying the WAF on a site as well as a series of practical examples. This paper expands on previous published work (Cote et al., 2009, Cote and Moran, 2009, Cote et al., 2012) in three ways. First, the previous work has focussed using the WAF to benchmark water performance across a region, while this work focuses on applying the WAF at a single site. Second, this work solely focuses on the Input-Output Model due to its adoption by members of the MCA. Third, this work contains lessons gained from the authors' experiences, including heuristics for deriving volumes on non-metered flows and information on how to represent some challenging configurations in the WAF.

This paper is organised as a step-by-step guide for onsite personal to implement the WAF. It begins with scoping instructions, outlining how to establish the site's system boundary and where to collect water information. It then describes how to implement the Input-Output Model, including identifying the pertinent components (inputs, outputs and diversions), quantifying flows, aggregating components, determining the quality of inputs and outputs and producing reports. It concludes with a set of lessons learnt and recommendations from the authors' experiences in implementing the WAF.

SCOPING

Determine Who Should Develop the Account

The first step in creating a water account is to identify who is responsible for developing the account. It is possible that the account be developed by an outside contractor or consultant. However, it is recommended that onsite personnel develop the account, as they have the best knowledge of the site's configuration and are best equipped to implement onsite improvements. The most appropriate person or team to develop the account will largely depend on the site's operational context. For example, in a site that mainly manages groundwater, the responsibility may lie largely with hydrogeologists; while, in a site that mainly manages surface water, the responsibility may largely lie with environmental scientists, Other sites may prefer to have a cross disciplinary team develop the accounts.

Establish System Boundary

The second step is to identify the system boundary. This will be used to separate water interactions that occur between the site and its surrounding context and those that occur within the site. Often, a sensible heuristic is to set the system boundary equivalent to the physical site boundary; however, as the system boundary is a conceptual rather than physical boundary, there are times when a site may choose to extend the system boundary, particularly to include facilities for which the site holds responsibility for, such as an offsite camp or an external concentrating plant.

Scope Information

The third step is to identify and gather relevant information about site water interactions. The information needs to identify the source of water entering a site, the destination of water leaving a site, where water is stored on site, the activities that use water on site and where water is treated on site. Given the complex nature of site water interactions, multiple individuals or groups, such as environmental, processing, mining or community relations teams may need to gather information both on and off site. Likewise, diverse types of information may need to be gathered, such as processing plant designs, meter readings, environmental and social impacts assessments or water contracts. Examples of required information and sources of this information are provided in **Error! Reference source not found.**.

<< Insert Table 1 Here >>

THE INPUT-OUTPUT MODEL

The Input-Output Model represents water interactions between the site and its surrounding environment and community. It describes how water enters the site, how it leaves the site and how the site manages water that it does not require for its operational purposes. It also describes the quality of water sources and destinations that the site interacts with, the accuracy with which these flows are reported and the site's surrounding socio-environmental context.

Identifying the Input-Output Model Components

The components in the Input-Output Model refer to the external water components that a site interacts with. Three types of components are required to be identified: inputs, outputs and diversions.

Identify Water Inputs

The first step in developing an Input-Output Model is to identify water inputs, that is, water that enters the operational facility external to the system boundary. Inputs consist of: physical water flows, such as those from rivers and lakes; non-physical water flows, such as ore entrainment; and water received directly from the environment such as rainfall, runoff and snowmelt. Inputs come from four sources of water: surface water, groundwater, sea water and third party water. These have been defined in previous work (Minerals Council of Australia, 2012) but, for completeness, are provided in Table 2.

<< Insert Table 2 Here>>

Identify Water Outputs

The second step of the Input-Output Model is to identify water outputs, that is, water that exits the operational facility to a destination external to the system boundary. Outputs consist of: physical water flows, such as discharges to rivers and lakes; non-physical water flows, such as entrainment in product or waste material and water sent directly to the environment, such as seepage and evaporation. There are five destination categories for the outputs: surface water, groundwater, seawater, third party water and other (includes evaporation, entrained water in products and tailings, task losses). Again, these have been defined in previous work (Minerals Council of Australia, 2012) and are also provided in Table 3.

<<Insert Table 3 Here>>

Separate Diversions from Site Inputs and Output

The third step of the Input-Output Model is to separate diversions from the flows that interact with onsite activities (site inputs and outputs). A diversion is any volume of water that the site actively manages but is not used by or intended to be used by an onsite activity. It is possible for diversions to be held on site for a long period of time (for example: several months) or mixed with other water that is intended to be used or has been used. Some examples of diversions include: water that is dewatered as part of the extraction process and then recharged to an aquifer; water that is taken from a river and returned at an appropriate time to sustain environmental flow or rainfall and runoff that is supplied to a community for beneficial use. These examples are expanded upon in the Challenging Configurations section of this paper, which also provides examples that would not be considered diversions with the WAF.

Quantifying Input and Output Flows

Once all the components on site have been identified, the next step is to quantify input, output and diversion flows. This is performed in four steps.

Connect Known Information to Flows

The first step is to identify what flow volumes are known and to connect them to the components identified in the previous step. This can be informed by the information and information sources gathered during the scoping step and by connecting this information to the appropriate inputs, outputs and diversions. Known flow volumes will usually be informed via records of water meters; however, flow volumes that are not directly metered can also be derived through calculations of known values. For example: the volume of water that is entrained in a run of mine (ROM) is equal to the ore's moisture content multiplied by the throughput over a given period. Other volumes may be derived from results of computer simulations. For example, it is common to use a hydrological model, such as the Australian Water Balance Model, to derive runoff volumes (Kunz and Woodley, 2013).

Investigate Unknown Information

The second step is to investigate information that is not known in order to fill information gaps. Either the information sources identified during the scoping study or new information sources can be used to fill these gaps. However, for many sites, particularly those that are inexperienced in developing water accounts, filling in all information gaps may be difficult due to time, technical and financial constraints. Based on this, sites may decide to prioritise which information gaps that they wish to investigate, particularly in the first few iterations of developing accounts.

Estimate Remaining Information Gaps

If information cannot be sourced for an individual flow then it needs to be estimated. Those developing accounts should try and use as much highly accurate measured and simulated information as possible to assist in their estimations and draw on their own experience and that of their peers in order to ensure the estimates are as accurate as possible. Examples of sensible estimates from the authors' experience are provided in the Quantifying Unknown Flows section of this paper

Determine Level of Confidence

The fourth step is to determine the level of confidence in the accuracy of the flow volumes which can either be high, medium or low. Since it is difficult to measure every flow on a mine site with a very high level of accuracy, the Level of Confidence attribute has been included within the WAF to allow sites to better understand their site configuration and identify areas for improvement. The Level of Confidence is a qualitative assessment based upon the opinion of the individual, group or company that is developing the account. For example, a site with a recently calibrated meter might set the confidence level to 'high' while one that has not been calibrated for a few years might set the confidence level to 'medium' or 'low'.

Aggregating Input-Output Model Objects

A key feature of the WAF is that information is communicated using the systems modelling paradigm. This means that pertinent information about the mine water interactions should be communicated clearly, even to a non-water expert, without overburdening them with too much detail. This is achieved by aggregating components based upon similarity or shared function. Components in the Input-Output Model that represent the same source, for example the rainfall and runoff that flows into the site, or similar sources, such as water that is intercepted from a group of aquifers, can and should be aggregated together.

Determine the Quality of Inputs and Outputs

Once the site's inputs and outputs have been defined, the next step is to classify their water quality. In other water accounting frameworks water quality is often not emphasised or even included since they often focus solely on water quantity. However, it has been included in the WAF in order to provide greater transparency and to improve social and environmental performance.

Currently, the MCA WAF has not yet prescribed use of specific water quality categories. The water quality categories can be determined by working through a decision tree. The current version (which is under consultation) is presented in**Error!**

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<< Insert Figure 2 Here >>

Producing Reports

There are three reports that can be produced from the Input-Output model: the Input-Output Statement, the Accuracy Statement and the Contextual Statement.

Input-Output Statement

The Input-Output Statement lists the water volumes and quality categories that flow into, out of and are diverted around mine site activities. Each input or output is listed separately. Diversions are listed in a separate table to site inputs and outputs.

Each input or output contains the following information:

1. Input/Output: A description of the specific input or output, for example, 'River Withdrawal' or 'Aquifer Interception'.
2. Source/Destination: The source or destination category (that is: surface water, groundwater, third party water or other) of the input or output.
3. Flow Quantity and Quality. The flow quantity should be expressed in a suitable unit (for example ML/yr) and categorised into a suitable quality.
4. How the flow was derived: Expressed as 'Measured', 'Simulated' or 'Estimated'.
5. Level of accuracy confidence: Expressed as 'High', 'Medium' or 'Low.
6. Notes Disclosures: A section of free text that explains how the flow information was derived. For example, information on the assumptions used to derive the flow quantity and quality or to determine the level of confidence.

Accuracy Statement

The Accuracy Statement provides a summary of how flow volumes for the inputs and outputs are derived and their associated level of confidence. The Accuracy Statement highlights where efforts can be made to fill gaps in information. The Accuracy Statement can be generated from the information in the Input-Output Statement. The following steps need to be undertaken to produce the Accuracy Statement:

1. For all 'Measured' inputs and outputs: sum together and record all the flows with a 'Low' confidence, repeat for all flows with a 'Medium' confidence level and then all the flows with a 'High' confidence level.
2. Repeat Step 1 for all 'Simulated' inputs and outputs.
3. Repeat Step 1 for all 'Estimated' inputs and outputs.
4. Represent the values as a percentage of all summed flows.

Contextual Statement

The Contextual Statement is a selection of free text that describes the surrounding socio-environmental region in which the site operates. The aim of the Contextual Statement is to provide broader socio-environmental information than is available in the other reports, which contain largely quantitative information. In order to produce the Contextual Statement it is important to set the geographical boundary of the 'context'. In many cases, a logical choice would be to set the context of the catchment in which the site is located or the boundary of its surrounding community; however, in some circumstances, it may be necessary to adjust the boundary of the contextual statement to encompass the area impacted by the mine (that is, the mine's footprint).

Some of the contextual environmental information that could be contained in the Contextual Statement includes:

1. Description of geographical terrain in which the operational facility is situated.
2. Catchment details.
3. Climatic conditions during the reporting period.
4. Information on water policy and rules applicable to the operational facility.
5. Administrative changes (for example, changes to water sharing plans).

The type of contextual social information that could be contained in the Contextual Statement is outlined in the Social Water Assessment Protocol (SWAP) (Collins and Woodley, 2013, Woodley and Collins, 2013). The SWAP is a scoping tool consisting of fifteen broad themes containing approximately sixty topics to demonstrate the types of information that should be considered. Each topic contains a set of questions which are intended to serve as prompts to establish a site's social water context. The SWAP also provides guidance on potential sources of primary and secondary information to consult. In addition to themes discussing physical water sources and climatic conditions (which could also be included in the environmental context) the following thirteen themes are contained in the SWAP:

1. Water supply and infrastructure.
2. Water used for local amenities.
3. Water used for domestic purposes.
4. Water use in the formal and informal economy.
5. Water interactions and significance of water to Indigenous peoples.
6. Cultural and spiritual values related to water.
7. Recreational use of water.
8. Human rights issues related to water.
9. Gender issues related to water.
10. Health issues related to water.
11. Interactions of other key local stakeholders with water.
12. Interaction between stakeholders in relation to water.
13. Legislation, policy and politics related to water.

LESSONS LEARNED AND RECOMMENDATIONS

Here we outline some of the lessons learned to provide recommendations collected by the authors over the past five years of implementing the WAF. This provides an extension to previous work on the WAF (Cote et al., 2009, Cote and Moran, 2009) which was focussed on its development phase. This section is broken up into two parts: first, a series of heuristics for estimating volume for flows that sites may not be able to measure with a meter or simulate and second, a set of challenging case studies regarding what is and what is not considered a diversion within the WAF.

Quantifying Unknown Flows

Throughout our experience in implementing the WAF we have noticed that few, if any, sites have the full set of information for all flows that need to be reported. However, it is imperative that this does not stop sites from producing a water account. In Table 4, we provide a set of heuristics that sites can use to calculate volumes for flows that they may not have measured.

<< Insert Table 4 Here >>

Challenging Case Studies

In our experience, deciding which flows to include in the account and whether the flows should be reported in the Input-Output Table or the Diversions Table of the Input-Output Statement have posed challenges to those developing Input-Output models.

On the first matter, deciding which flows need to be reported is to answer the question of materiality of the flows; is knowledge of the flows necessary to understand and use the water account for mine water management purposes? If the answer is 'yes' then the flow is material and needs to be included in the Input-Output, otherwise the flow is immaterial and does not need to be included. In general, small flows, such as leaks, do not need to be included in the Input-Output Statement. However, the scope of materially is broader than just volume. For example, is a mine produces acid and metalliferous drainage then that flow should be reported, even if it is very small volume.

Regarding the second matter, in order for a water flow to be considered a reportable diversion under the WAF with disclosure of flow volumes in the Diversions Table, it needs to:

1. Enter and exit the site;
2. Not be used for any onsite activities; and
3. Be actively managed by the site in some way.

Here we provide a series of eight challenging case studies. They are based on questions that have arisen from workshops with corporate and mine site personnel. regarding diversions. The first three case studies are not considered diversions within the WAF since they fail to meet one or more requirements above, while the remaining five case studies would be considered as diversions within the WAF.

Case Study 1: River Diverted Around or Through Mining Lease

In this example, the flow of a river is diverted around or through a mine site. As long as the water in the river does not come into contact with infrastructure that the mine actively manages (such as pipes) the river diversion would not need to be included in the Input-Output Statement but should be mentioned in the Contextual Statement.

Case Study 2: Water Entrained in Overburden

This example concerns water that is entrained in overburden. The water in the overburden is immaterial as the waste does not leave the site but is just moved water from part of the site to another. Based on this it does not need to be included in the Input-Output Statement

Case Study 3: Rainfall that Fails to Become Runoff

This example concerns water that falls within the site boundary and fails to become runoff, instead either infiltrating into the ground or evaporating. Again, since the rainfall is not actively managed on site it does not need to be included in the Input-Output Statement.

Case Study 4: Water that is Intercepted from Aquifers and exits the site without been used

This example concerns water that is intercepted from aquifers and exits the site via reinjection, evaporation or discharge, without previously being used for onsite activities. This is an example of a diversion within the WAF that must be reported in the Diversions Table.

Case Study 5: Rainfall that Becomes Runoff within an Actively Managed Area and Exists the Site Without Use

This example concerns rainfall that becomes runoff within an actively managed area, such as runoff into storage dams or that collects within mine infrastructure such as pipes or canals and then exists the site, either through discharge, evaporation, seepage or other means, without use. Since the runoff comes into contact with an actively managed area, in contrast with Case Study 3, it needs to be reported as a diversion within the WAF.

Case Study 6: Water that is Held in Storage before Exiting Site without Use

This example concerns water that is held in storage for a period of time and exits the site without being used for onsite purposes. This example would be considered a diversion, even though the water may remain onsite for a long time period or may mix with water that is used for an onsite activity.

Case Study 7: Water that is Used to Offset Negative Environmental and Social Impacts

This example concerns water that is accessed and exits the site to offset a negative environmental impact or social impact. An example of an environmental offset is when water is used to return a stream to its natural flow, while an example of a social offset is a 'make-good' agreement that the mine may have with a local agriculturist to compensate for lost water due to drawdown. This case would be considered a diversion with special reference made within the notes discourse, and also possibly the contextual statement, that it acts as an offset.

Case Study 8: Water that is Used to Provide Environmental and Social Benefits

This example concerns water that is accessed and exits the site to provide an environmental or social benefit. For example, a site may withdraw water from an aquifer and then supply to the local community for livelihood or domestic purposes. As with the previous example, this case would be considered a diversion with special reference made within the notes discourse, and also possible the contextual statement, on the fact that it provides an environmental and social benefit.

CONCLUSION

This paper has presented a robust methodological approach for representing mine site water interactions in accordance with MCA's WAF. This work is particularly pertinent considering the adoption of the WAF's Input-Output Model by members of the MCA both within Australia and globally. The paper described how to scope information for formulating a water account, how to produce the WAF's Input-Output Model and lessons learned and recommendations for handling unknown flows and challenging scenarios. It is hoped that this paper will further increase the adoption of the WAF and improve the consistency of the accounts produced, leading to better water management and sustainability outcomes for the mining industry.

REFERENCES

BHP BILLITON 2013. Sustainablity Report 2012. Melbourne, Australia.

COLLINS, N. & WOODLEY, A. 2013. Social water assessment protocol: a step towards connecting mining, water and human rights. *Impact Assessment and Project Appraisal* 31.

COTE, C. & MORAN, C. 2009. A Water Accounting Framework for the Australian Minerals Industry. *Sustinable Development Indicators for the Minerals Industry.* Gold Coast, Australia.

COTE, C., MORAN, C., RINGWOOD, K. & CUMMINGS, J. Developing a Water Accounting Framework for the Australian Minerals Industry. Water in Mining 2009, 2009 Perth, Australia. Australian Insitute of Mining and Metallurgy, 191-204.

COTE, C. M., CUMMINGS, J., MORAN, C. J. & RINGWOOD, K. 2012. Water Accounting in Mining and Minerals Processing. *In:* GODFREY, J. M. & CHALMERS, K. (eds.) *Water Accounting.* Cheltenham, England: Edward Elgar Publishing Limited.

GEOSCIENCE AUSTRALIA. 2013. *Minerals Basics* [Online]. Available: http://www.ga.gov.au/minerals/basics.html [Accessed 14/8/2013 2013].

KUNZ, N. & WOODLEY, A. 2013. Improving the accuracy of mine site water balances through improved estimation of runoff volumes. *Water in Mining Conference 2013.* Brisbane, Australia.

MINERALS COUNCIL OF AUSTRALIA 2012. Water Accounting Framework for the Minerals Industry.

MINERALS COUNCIL OF AUSTRALIA. 2013. *MCA Member Companies* [Online]. [Accessed 14/8/2013 2013].

MORAN, C., COTE, C., MCINTOSH, J., HEDEMANN, C. & SILVERSTER, N. 2006. ACARP Project 15001 Final Report: Northern Bowen Basin Water and Salt Management Practices. Centre for Water in the Minerals Industry, Sustainable Minerals Insititute, University of Queensland.

WOODLEY, A. & COLLINS, N. Using the SWAP to connect water, human rights and mining. International Association of Impact Assessment, 2013 Calgary, Canada.

FIGURE CAPTIONS

Figure 1. Water Accounting Framework's Input-Output and Operational Models

Figure 2. Decision tree for categorising water quality

TABLE CAPTIONS

Table 1.. Common information and sources required for accounts

Table 2. Source categories of Inputs and definitions

Table 3. Destination categories of Outputs and their definition

Table 2. Heuristics for calculating unknown flows on site

FIGURES

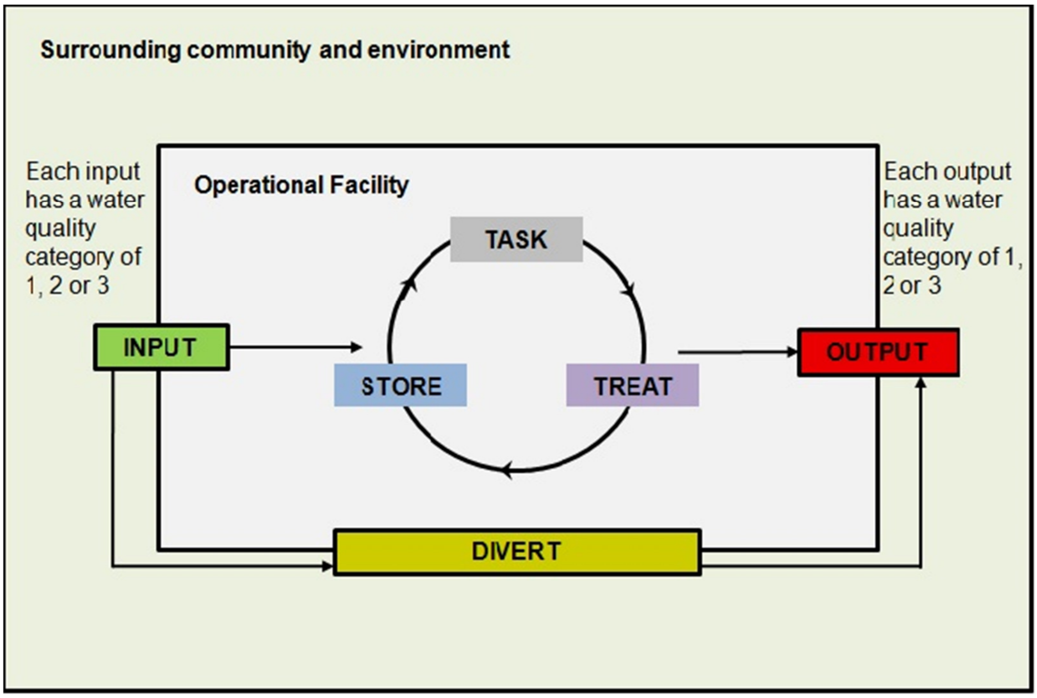

Figure 3. Water Accounting Framework's Input-Output and Operational Models

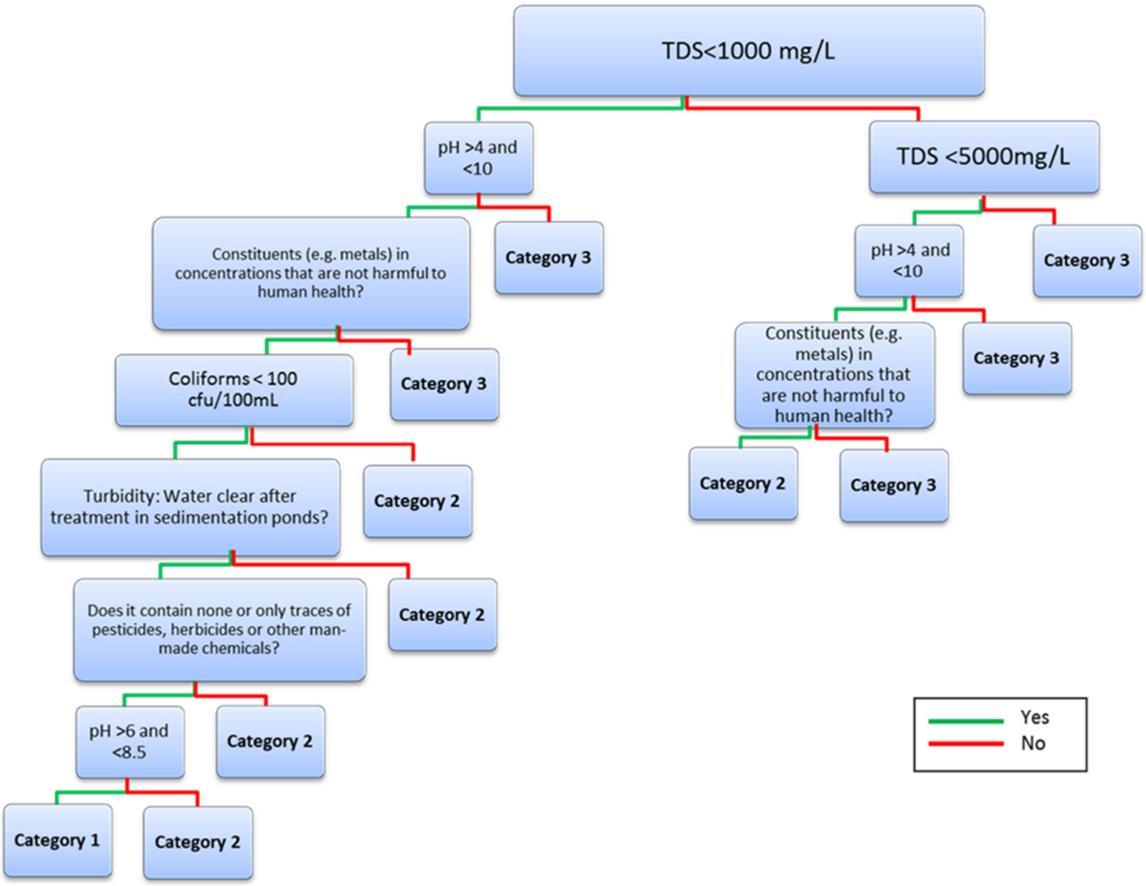

Figure 4. Decision tree for categorising water quality

TABLES

Information sources	Information to source
The Hydrogeology Team	• Volume and quality of extracted groundwater
Mining Team	• Volume of water used for extraction of material • Volume of water used for dust suppression on roads and pit • Volume of water used for vehicle wash down • Volume of water used for dust suppression of material
Processing Team	• Processing plant flowcharts • Volume and quality of water flowing into the processing plant • Any return flows from the processing plant to water stores • Throughput of run-of-mine (ROM) material that is processed • Quantity of production and waste material (both coarse and fine waste) • Moisture content of ROM, product and waste • Quantity and moisture content of material sent to concentrators
The Environmental Team	• Climate data such as rainfall, runoff and evaporation • Volume and quality required to meet environmental flows • Volume and quality of discharge • Water management plan • Information on stores such as: store volumes at beginning and end of reporting period, surface areas and catchment areas
Operations	• Volume and quality of water that is purchased by the site • Volume and quality of water that is sold by the site • Drainage management • Flow meters • Potable water supply • Return flows from tailings storage facilities and concentrators • Volume of water treated on site

Community Relations Team	• 3rd party contracts with local stakeholders including 'make-good' agreements or water provided free of charge • Information concerning the social context (Collins and Woodley, 2013, Woodley and Collins, 2013) that sites operate in.

Table 1. Common information and sources required for accounts

Source	**Definition**
Surface Water	All water naturally open to the atmosphere, except for water from oceans, seas and estuaries
Groundwater	Water beneath the earth's surface that fills pores or cracks between porous media such as soil, rock, coal, and sand, often forming aquifers. For accounting purposes, water that is entrained in the ore can be considered as groundwater
Sea Water	Water from oceans, seas and estuaries
Third Party	Water supplied by an entity external to the operational facility. Third-party water contains water from the other three sources. When the source is known, the physical source (surface water, groundwater, sea water) should prevail.

Table 2. Source categories of Inputs and definitions

Destination	Definition
Surface Water	All water naturally open to the atmosphere, except for water from oceans, seas and estuaries
Groundwater	Water beneath the earth's surface that fills pores or cracks between porous media such as soil, rock, coal, and sand, often forming aquifers.
Sea Water	Water to oceans, seas and estuaries
Third Party	Water supplied to an entity external to the operational facility.
Other	Includes evaporation, entrainment, task loss and any other destination that is not covered by the other pathways.

Table 3. Destination categories of Outputs and their definition

Description	**WAF Representation**	**Heuristic**
Direct rainfall onto storage facilities	Input-Surface Water-Precipitation and Runoff	Sum of storages' surface areas multiplied by rainfall over reporting period
Runoff into storage facilities	Input-Surface Water-Precipitation and Runoff	Sum of storages' catchment areas multiplied by rainfall over reporting period multiplied by a rainfall-runoff coefficient.
Entrainment in the run of mine (ROM) ore that gets feed into the processing plant	Input-Groundwater-Entrainment	ROM throughput during reporting period multiplied by moisture content of the ore (typically 3%-7%)
Evaporation from storage facilities	Output-Other-Evaporation	Sum of storages' surface areas multiplied by evaporation over reporting period multiple by a pan evaporation factor (typically 0.75)
Evaporation from water used for dust suppression on haul roads	Output-Other-Evaporation	Length of haul roads multiplied by a water use factor (typically 2 -3 ML/KM)

Evaporation from water added to product to aid dust suppression; particularly on sites that use 'dry' processing techniques	Output-Other-Evaporation	Volume of water used for dust suppression on product multiplied by a evaporation factor (typically 0.1 since most water will remained entrained in the ore)
Entrainment in fine waste such as tailings	Output-Other-Entrainment	Moisture content of fine waste multiplied by mass of fine waste
Entrainment locked within product from water added to aid dust suppression; particularly on sites that use 'dry' processing techniques	Output-Other-Entrainment	Volume of water used for dust suppression on product multiplied by a entrainment factor (typically 0.9 since most water will remained entrained in the ore)
Entrainment within product and coarse waste; particularly on sites that use 'wet' processing techniques	Output-Groundwater-Entrainment	Sum of inflows into processing plant minus other outflows (for example return flow and flow to tailings) split proportionally between product and waste.
Water lost from amenities, office and camp	Output-Other-Task Loss	Usually assume that all water sent to these activities is lost

Table 4. Heuristics for calculating unknown flows on site